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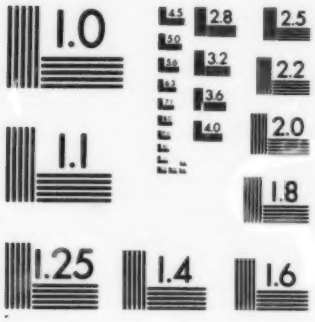

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Canadian Aviation Safety Board

Bureau canadien de la sécurité aérienne

Civil Aviation Occurrence Report

Canada

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The Canadian Aviation Safety Board investigated this occurrence for the purpose of advancing aviation safety. It is not the object of the Board to determine or apportion any blame or liability.

AVIATION OCCURRENCE REPORT

CESSNA 411 C-GQSP
OSHAWA, ONTARIO
16 DECEMBER 1986

REPORT NUMBER 86-Ø60106

SYNOPSIS

The aircraft was on an instrument flight rules flight from Toronto, Ontario to Oshawa, Ontario when a malfunction in the landing gear system led the pilot to attempt to lower the landing gear, using the emergency landing gear extension procedure. The pilot was unable to determine the position of the landing gear to his satisfaction, and he carried out two missed approaches. During the second missed approach, both engines lost power while the aircraft was over a residential area, adjacent to the airport, and the aircraft descended and struck a house. Both occupants of the aircraft were seriously injured, as were both occupants of the house.

The Canadian Aviation Safety Board determined that, immediately following take-off, the two landing gear motor lugs failed in overload and shear. The landing gear and other technical problems so occupied the pilot's attention that he did not manage fuel consumption. The engines stopped because of fuel starvation.

Ce rapport est également disponible en français.

15 June 1988

Canada

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1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 16 December 1986, the aircraft, a Cessna 411, registration C-GQSP, was on a private ferry flight from Toronto/Lester B. Pearson International Airport to Oshawa, Ontario. On board was the pilot and one passenger. The aircraft departed at 1635 eastern standard time (EST)* on an instrument flight rules (IFR)** clearance from runway 06 Left. When the aircraft became airborne, the pilot selected the landing gear up. The three green gear-down indicator lights extinguished, and the pilot heard a loud noise described as a "clunk"; no gear-up indication was obtained. The pilot next observed that his number two communications radio and transponder were not working. He levelled the aircraft below his assigned altitude to maintain visual flight rules (VFR) flight conditions and continued to his flight-planned destination.

On approaching Oshawa, the pilot selected the landing gear down, but the three green gear-down lights did not illuminate. The emergency landing gear extension procedure was attempted, but a gear-down indication was still not obtained. The pilot circled the airport and continued the approach until the round-out but overshot at that time as he was unsure that the landing gear was down. The pilot flew a second circuit and carried out a second approach, but this time he felt the aircraft was too fast and too high on final approach and was not in position to touch down until at a point where insufficient runway remained to complete the landing. The pilot again overshot, and, during the climb-out, the right engine lost power. The aircraft swung to the right, and, almost immediately, the left engine lost power. The aircraft descended and crashed through the rear wall of a house, coming to rest in the main floor rooms of the house (see Appendix A). The pilot and passenger received serious injuries as did both occupants of the house.

* All times are EST (Coordinated Universal Time (UTC) minus five hours) unless otherwise stated.

** See Glossary for all abbreviations and acronyms.

The accident occurred at lat 43°55'N, long 78°54'W***, at an elevation of 450 feet above sea level (asl), at 1707 EST during the period of twilight.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	1	1	2	4
Minor/None	-	-	-	-
Total	1	1	2	4

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Two houses, a garage, and a car were damaged by the aircraft. The roofs of the first house and garage received minor damage; the second house was damaged to the extent that it had to be demolished. The automobile received damage to the hood and windshield.

1.5 Personnel Information

	Pilot-In-Command
Age	37
Licence	Commercial
Medical Expiry Date	01 September 1987
Total Flying Time	3,689 hr
Total on Type	10 hr
Total Last 90 Days	200 hr
Total on Type Last 90 Days	10 hr
Hours on Duty Prior to Occurrence	7 hr
Hours off Duty Prior to Work Period	12 hr

In addition to his Canadian commercial licence, the pilot held Airline Transport pilot licences for the United States and for Fiji. Examination of the pilot's Canadian and American training histories indicated that he met the standards for his various licences and endorsements.

*** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

The 10 hours on type consisted of five hours as co-pilot in the right seat and five hours as pilot-in-command. Of the five hours as pilot-in-command, 2.4 hours were flown with a type-qualified pilot in the right seat to complete the check-out on type.

In interviews after the accident, the pilot demonstrated an adequate knowledge of Cessna 411 operating limitations and normal operating procedures; however, he lacked an in-depth understanding of the aircraft systems that he had to analyse during the accident flight.

1.6 Aircraft Information

Manufacturer	Cessna Aircraft Company
Type	Cessna 411
Year of Manufacture	1966
Serial Number	411-0141
Certificate of Airworthiness	Valid
Total Airframe Time	4,256 hr
Engine Type (2)	Continental TGSIO-520-C
Propeller Type (2)	Hartzell HC-A3VF-2D
Maximum Allowable Take-off Weight	6,500 lb
Recommended Fuel Type	100/130

The aircraft was certified and equipped in accordance with the applicable regulations, and the weight and centre of gravity were within the prescribed limits.

1.7 Meteorological Information

The weather at Oshawa was broken cloud based at 1,500 feet above ground level (agl), and the visibility was eight miles in haze. The wind was from 330 degrees at five knots, and the altimeter was 30.24 inches. The time of the start of official night (30 minutes after sunset) was 1708 EST.

1.8 Aids to Navigation

The flight was initially operating under an IFR clearance in VFR flight conditions. When electrical power was lost to the radios, the pilot maintained VFR conditions, and no radio navigational aids were used to complete the flight.

1.9 Communications

Prior to take-off, communications had been established with Toronto Clearance Delivery, Toronto Ground Control, and Toronto Tower. All communications had been satisfactory; there were no intermittent transmissions or other indications of radio or electrical problems. There were no transmissions received from the aircraft by any radio station after the take-off.

1.10 Aerodrome Information

Oshawa Airport has three paved runways, 04/22, 08/26, and 12/30. The active runway was runway 30. The runway used by the pilot for the approaches and attempted landings was runway 12; it was 3,476 feet long and 150 feet wide. The runway lights for runway 12/30 were on and set to strength three; there were no approach lights for any of the runways. A visual approach slope indicator system (VASIS) was available on runway 30 only. Lighted wind indicators (wind socks) were located to the north side of runway 12/30 and to the south side of runway 04/22.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was either required by regulation.

1.12 Wreckage and Impact Information

During the descent, the fully extended landing gear struck the roof of a house, and the aircraft veered about 45 degrees to the left. The descent continued, and the lower surface of the left stabilizer struck the roof of a garage. The left tip tank then struck and penetrated the windshield of a parked car. The aircraft swung an additional 45 degrees to the left and penetrated the rear wall of a frame house, just above the top of the concrete foundation. The three landing gear legs were sheared from the aircraft by the impact with the cement foundation. After the impact, the upper red anti-collision light continued to operate for a short period of time. The instrument lights on the pilot's instrument panel remained on, and the amber door-ajar light was illuminated until the master switch was turned off.

Examination of the wreckage started less than one hour after the impact. The right tip tank had been torn from the aircraft and split in two sections by the impact. The front section of this tank was sitting in a nose-down attitude and contained less than one gallon of fuel. The nose of the left tip tank had ruptured when it penetrated the windshield of the parked car, and all the contents of the tank had drained into the interior of the car. The odour of fuel was very strong in the car, but the quantity of fuel was not sufficient to form pools or be visible in any way. The right auxiliary fuel tank cells had ruptured, and the contents had spilled. The left auxiliary fuel tank was leaking but appeared to be almost full. Both aircraft fuel selectors were selected to the main tanks, and the feed lines to both engine-driven fuel pumps were empty.

All cockpit lighting control rheostats, except the pilot's instrument lights, were turned down or off. All circuit-breakers were in (on), with the exception of the cabin light circuit-breaker and one of each pair of 50 amp main bus circuit-breakers. The cabin light circuit is hot-wired to the battery and remains live when the master switch is turned off.

It was determined that the landing gear motor mounting flange had failed prior to the aircraft striking the house. Except for the failure of the landing gear motor mounting flange, there were no mechanical discrepancies observed that would have contributed to the accident.

1.13 Medical Information

There was no evidence that incapacitation, physiological, or psychological problems affected the pilot's performance.

1.14 Fire

There was no evidence of fire found either before or after the occurrence.

1.15 Survival Aspects

The accident was survivable. The nose and windshield of the aircraft were driven back onto the occupants of the front seats. Emergency rescue equipment was required to move the aircraft structure so that the occupants could be removed from their seats. The passenger compartment and passenger seats remained intact.

1.16 Tests and Research

Examination of the landing gear motor and the mounting flange showed that the motor had become disconnected from the flange when the two mounting lugs on the flange failed. Laboratory analysis (LP 12/87) indicated one lug failed as a result of an overload shear and the second lug failed because of time-dependent progressive shear. The time between the two failures could not be determined.

Laboratory examination (LP 4/87) determined that the radio master switch was in the OFF position at the time of impact. All radios except the number two communication radio were located in the nose of the aircraft and were destroyed on impact. The number two communication radio, which was being used during the take-off, was removed, checked, and found to be serviceable. The radio bus relay, circuit-breakers, and wiring were checked and found to be serviceable.

A Cessna 411 was test flown to determine the air speeds and fuel consumptions at various power settings and flight configurations. At idle, the engines were consuming approximately 10 U.S. gallons per hour (gph) per engine. On take-off and during an overshoot at full throttle, the fuel flow was 39 to 40 gph per engine. At a climb power setting of 75 per cent and the mixture set to full rich, the fuel flow was 26 gph per engine. In level flight at 65 per cent power, the engines each consumed 14 to 20 gph, depending on the setting of the mixture control. At this power setting, the indicated airspeed was 140 knots with the landing gear extended and 200 knots with the landing gear retracted. On approach, the engines each consumed 17 gph when the mixtures were set to full rich, and, during a circuit, the fuel flow was 22 gph when the aircraft was flying the downwind leg in level flight and at an airspeed of 140 knots. The Cessna performance charts indicate that the fuel quantity required for start, taxi, take-off, and climb is 7 gallons to an altitude of 2,000 feet, 10 gallons to 5,000 feet, and 15 gallons to 10,000 feet.

1.17 Additional Information

1.17.1 Landing Gear

The landing gear is mechanically operated through a system of push rods and bellcranks connected to an actuator, which is driven by an electric motor. One end-flange of the motor is bolted directly onto the gearbox of the actuator. The landing gear actuator is

located aft of the main spar, below the cabin floor to the rear of the pilot's seat. Up-limit and down-limit switches are mounted on the actuator and operated by the upper bellcrank which is connected to the main landing gear push rods. The normal rigging of these switches stops the motor before the sector gear contacts the internal stops in the actuator. Electrical power is supplied to the landing gear motor through the landing gear relays from the LDG GEAR circuit-breaker. The three green landing gear-down indicator lights are controlled by microswitches mounted on each landing gear leg. These switches close and illuminate the green lights on the instrument panel when the landing gear is fully extended and the side braces have travelled overcentre to the locked position. When all three landing gear are fully retracted, the amber gear-up light is illuminated; there is no in-transit light or other indication when the landing gear is in an intermediate position.

Electrical power is fed directly to the four landing gear indicator lights from the GEAR & STALL WARNING circuit-breaker, and the lights are illuminated by the microswitches completing the circuits to ground. The lights incorporate a self-test feature; pressing the light lens assembly causes the light to illuminate, confirming that the bulb is serviceable and that there is power to the circuit.

The landing gear is selected up or down by a switch located near the lower edge of the instrument panel, to the left of the throttle quadrant. The landing gear emergency extension system is operated by a hand-crank located below, and to the right, of the pilot's seat. Unlatching the hand-crank disengages the electric motor from the system and engages the hand-crank. Approximately 52 turns of the crank are required to fully extend the landing gear from the full-up position. The emergency system procedure specifies that the LANDING GEAR circuit-breakers be pulled prior to manual extension of the landing gear. This is to prevent accidental operation of the motor and injury from the hand-crank.

Instructions for the operation of the emergency landing gear extension system appear in three locations: on a placard near the emergency extension crank; in the Federal Aviation Administration (FAA) approved aircraft flight manual; and in the owner's handbook. The wording of these instructions is different in each location, and the identification of the circuit-breakers in the instructions is not consistent with the placarding of the circuit-breakers. The FAA approved flight manual instructs the pilot to pull circuit-breakers, whereas only one breaker is to be pulled.

1.17.2 Electrical System

Electrical power is supplied by two 100-ampere alternators, one mounted on each engine. The left alternator is connected to the left electrical bus through two 50-ampere feeder circuit-breakers, which are connected in parallel, and the right alternator is similarly connected to the right electrical bus. The two buses are interconnected by a bus tie. There is no provision for the pilot to isolate either bus from the electrical circuit.

The battery is connected to both buses through the battery relay controlled by the battery master switch.

The navigation and communication radios and the radar are connected to the radio bus, which is fed through a circuit-breaker and relay from the right electrical bus. The radio bus relay is activated by closing the radio master switch.

The electrical load of the aircraft is divided between the two electrical buses. Included in the systems connected to the left bus are the left fuel pump, the left transfer pump, the red anti-collision lights, the left landing light, the left engine gauges, and the co-pilot's instrument lights. The right bus supplies power to the right fuel pump, the right transfer pump, the right landing light, the landing gear operating circuit, the landing gear warning horn and lights and stall warning horn circuit, the right engine gauges, the engine instrument lights, the pilot's instrument lights, the radio bus, and the door-ajar warning light in addition to other systems.

1.17.3 Fuel System

The aircraft fuel is carried in two main tip tanks, which have a capacity of 50 U.S. gallons each, and two auxiliary tanks located in the wings, each with a capacity of 35 U.S. gallons (see Appendix B). Each main (tip) fuel tank contains a boost pump and a transfer pump, which are electrically operated. The boost pump maintains a constant fuel pressure to the engine-driven fuel pump whenever the main tanks are in use; the transfer pump operates continuously and transfers fuel from the front of the tip tank to the rear to maintain a constant supply of fuel at the boost pump pick-up and to prevent fuel starvation when the fuel quantity falls below 10 gallons and the aircraft is in a nose-down attitude, as during a descent. There are no pumps in the auxiliary tanks which are recommended for use in level flight only. The fuel volume delivered to the fuel

injector exceeds the requirements of the engine, and the excess fuel is returned to the main tank regardless of whether the main tank or the auxiliary tank is supplying the fuel. Correct operating procedure requires that the main tanks be selected for take-off and landing and that the main tanks be used for a minimum of one hour before the auxiliary tanks are selected, to prevent the returned excess fuel from overfilling the main tanks and venting overboard.

The aircraft had been fuelled to capacity in Oshawa the day prior to the accident. The aircraft then completed a test flight of about a one-hour duration, during which it climbed to 10,000 feet. It then landed and taxied to a hangar. The following day, the aircraft was taxied to a second hangar for an attempted automatic direction finder (ADF) radio repair, then later restarted and flown to Toronto. Following radio maintenance in Toronto, the aircraft departed for Oshawa and, during this flight, the accident occurred. The main tanks had been used for all flights since the aircraft was last refuelled.

The calculated minimum fuel required for these three flights would have been 81 U.S. gallons, if the engines were leaned for maximum economy. This does not allow fuel for taxi to the hangar after refuelling or from the hangar to the radio shop, nor for the overshoot, circuit, and start of the second overshoot. Operating the engines at a rich setting of 18 gph while in cruise would have required at least 97 U.S. gallons of fuel, plus taxi and overshoot requirements.

1.17.4 En Route Observations

The pilot noted that the aircraft had cruised at 140 knots instead of 200 knots during the flight from Toronto to Oshawa. The power was set at about 65 per cent, and the fuel flows were not leaned to the normal lean setting. It had been the pilot's policy to operate the engines two to four gph richer than the recommended lean cruise setting. He also noted that only the pilot's instrument panel lights were illuminated. The pilot checked at this time and noted that both alternators were functioning.

The emergency landing gear extension procedure was attempted, but the pilot was able to turn the hand-crank only four turns before the movement was restricted. The green gear-down lights did not illuminate.

2.0 ANALYSIS

2.1 Introduction

The pilot experienced what he perceived to be a combination of malfunctions after take-off. At his destination, while he was still trying to resolve these problems, both engines stopped unexpectedly. The analysis focuses on the nature of the malfunctions and the pilot's attempts to deal with them.

2.2 Landing Gear Retraction Failure

When the landing gear was selected up during the climb-out from Toronto, the landing gear started to retract. During the retraction cycle, the pilot heard a clunk and noted that, although he no longer had a gear-down indication, he did not have a gear-up indication either. This noise was the landing gear motor striking the aircraft belly skins after the failure of the landing gear motor mounting flange. When the mounting flange failed, the gear was left in a partially retracted position. In this position, neither the gear-up nor the gear-down lights would be illuminated. This gear extended position was confirmed by the slow (140-knot) cruise speed noted by the pilot.

Although the reason for the landing gear motor mounting flange failure was not determined, it was shown that the first lug failed as a result of an overload and the second lug failed because of a time-dependent progressive shear. This indicates that the load which caused the initial overload failure was not parallel to the axis of the motor or it would have been felt equally by the other lug. This type of load could have been imposed by someone stepping or kneeling on the motor when the cabin floor boards were removed for maintenance purposes. The time period between the original failure and the secondary failure could not be determined.

2.3 Reported Electrical Failure

After hearing the clunk of the landing gear motor, the pilot noted the loss of all navigation and communication radios, which occurred just after take-off and the selection of the landing gear to the UP position. The pilot interpreted this to be a total electrical system failure even though he observed that both alternators were functioning and that the electrically operated engine gauges continued to operate. He did not test the gear indication lights to determine their serviceability.

The flight had taken off in daylight, and it continued until darkness fell. During this time, the pilot's instrument lights became visible, but the other instruments lights were not on. This was due to the fact that the light control rheostats were turned down on all cockpit lights, except the pilot's instrument panel, and he did not try to change their settings.

Several witnesses at the Oshawa Airport observed the aircraft at dusk with only the upper and lower red anti-collision lights illuminated; no other external lights were visible. The pilot had made no attempt to turn on any of the lighting systems after the suspected electrical failure.

Power to the anti-collision lights is supplied from the left power bus, and power to the pilot's instrument lights is supplied from the right power bus. Therefore, power must have been available to both buses during the flight.

The loss of electrical power to the radios was due to the radio master switch being inadvertently turned off at some point following the take-off. It could not be determined why the switch would have been turned off.

2.4 Landing Gear Extension

The failure of the landing gear motor did not prevent the operation of the landing gear emergency extension system. As the landing gear had only moved a small amount from the down-and-locked position, only four turns of the hand-crank were required to extend the landing gear fully. Because the GEAR & STALL WARNING circuit-breaker was pulled during the emergency extension procedure, the gear warning circuit was deactivated, and the green lights were not illuminated when the gear was fully down. The inconsistencies in the emergency landing gear extension procedures may have contributed to this situation. The pilot did not test the gear warning lights to determine if the failure of the lights to illuminate was due to a failure in the warning circuit or was the result of the landing gear not being fully extended.

The lack of a gear-down light indication and the inability to turn the hand-crank more than four turns was incorrectly interpreted by the pilot to be a condition in which the landing gear was jammed and not fully extended.

2.5 The Engine Failures

The fuel required for the flights conducted since the aircraft was last refuelled was between 81 and 97 U.S. gallons, plus that required for taxiing and overshooting. The usable fuel in full main tanks is 100 U.S. gallons. All these flights were conducted with fuel being supplied from the main tanks. The lack of fuel in the main fuel tanks and the engine-driven fuel pump feed lines indicates that the engine power loss was due to fuel starvation.

The pilot did not monitor the fuel state and thus did not utilize the fuel available in the auxiliary fuel tanks; as a consequence, all usable fuel in the main tanks was exhausted.

2.6 Pilot Actions and Decisions

The pilot had to deal with one real malfunction in the aircraft - the landing gear - along with what appeared to him to be a total electrical system failure. He was unsuccessful in resolving these problems, and, in the course of his trouble-shooting, all fuel was exhausted from the main tanks.

With 3,689 total flying hours, the pilot has considerable experience, and there was nothing in his previous training background to explain his inability to deal with the malfunction. His check-out on the Cessna 411 was brief but typical for this type of operation, and he displayed an adequate knowledge of basic operating procedures. The pilot's lack of a systematic approach to his trouble-shooting and the erroneous conclusions he reached about the status of various systems indicate that his judgement was clouded by the stress of the situation. His lack of an in-depth knowledge of the aircraft systems also contributed to both the stress level and to his inability to rectify the systems problems.

The pilot's decision to leave the Toronto area and continue to his destination with known aircraft problems and in waning light conditions was not in accordance with good operating practices.

3.0 CONCLUSIONS

3.1 Findings

1. The two landing gear motor mounting lugs failed, the first in overload and the second because of time-dependent progressive shear.

2. The pilot inadvertently turned off the radio master switch during the flight.

3. The failure of the landing gear motor mounting flange resulted in the landing gear remaining in an extended position, but not fully down-and-locked.

4. There were inconsistencies in three published emergency landing gear extension procedures.

5. The pilot pulled the GEAR & STALL WARNING circuit-breaker, did not test the gear warning system when the gear-down lights did not illuminate, and overshot when it was not necessary to do so.

6. The pilot did not follow systematic trouble-shooting procedures and misinterpreted several cockpit cues as complete electrical failure.

7. The pilot did not adequately manage fuel consumption, resulting in fuel starvation and loss of engine power while fuel remained in the auxiliary tanks.

8. The pilot was certified and qualified for the flight in accordance with existing regulations.

9. The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

10. The weight and centre of gravity were within the prescribed limits.

3.2 Causes

Immediately following take-off, the two landing gear motor lugs failed in overload and shear. The landing gear and other technical problems so occupied the pilot's attention that he did not manage fuel consumption. The engines stopped because of fuel starvation.

4.0 SAFETY ACTION

4.1 Action Taken

4.1.1 Flight Manuals - Landing Gear Emergency Procedures

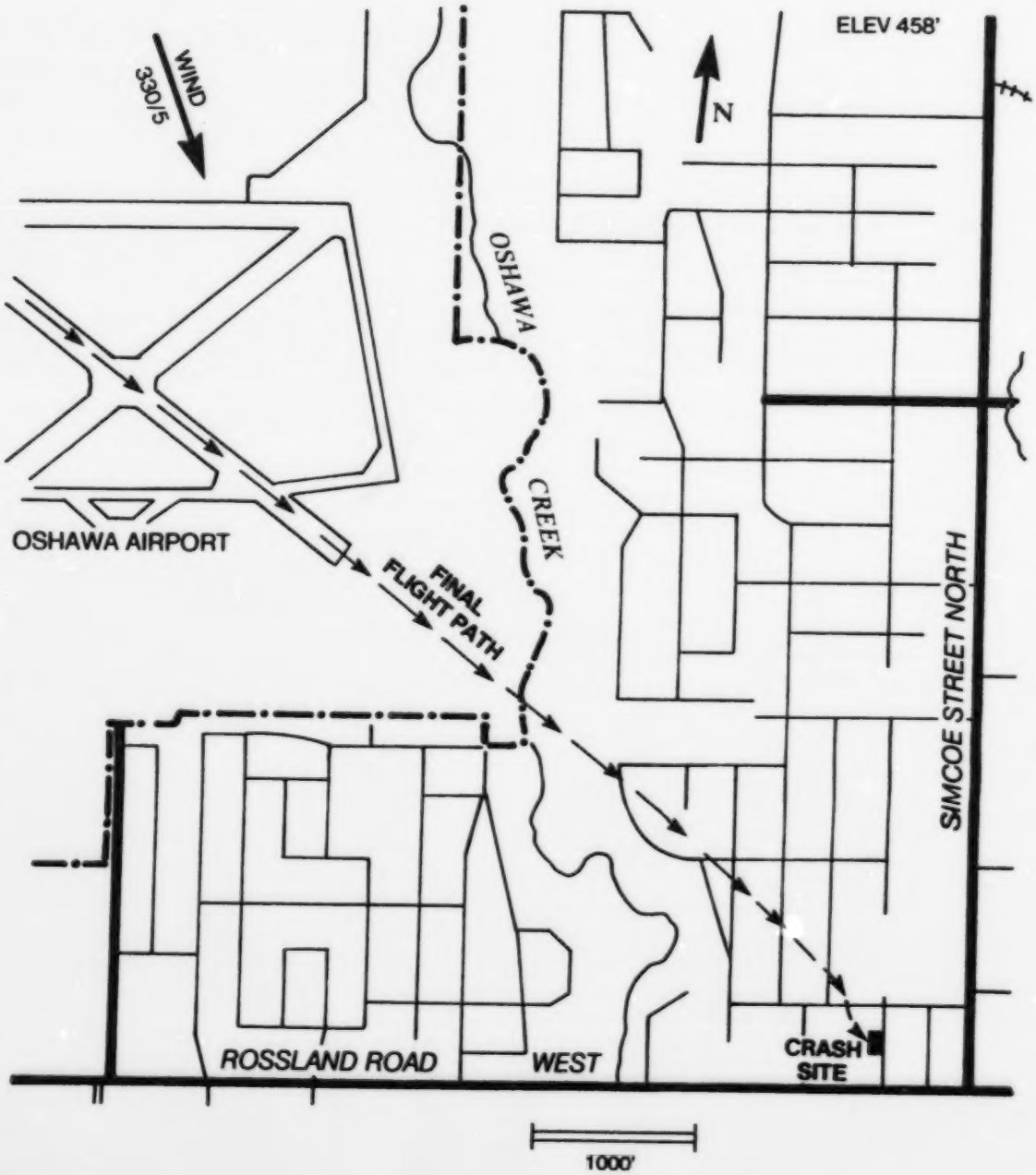
The Canadian Aviation Safety Board forwarded an Aviation Safety Advisory to the Department of Transport, addressing the fact that the emergency landing gear lowering procedure described in the Cessna 411 Flight Manual could be misleading. On 30 July 1987, Transport Canada issued Service Difficulty Alert No. 87-06 advising Canadian Cessna aircraft owners of the potential for misunderstanding the emergency landing gear lowering procedures and identifying the correct procedures to be used.

4.2 Safety Concern

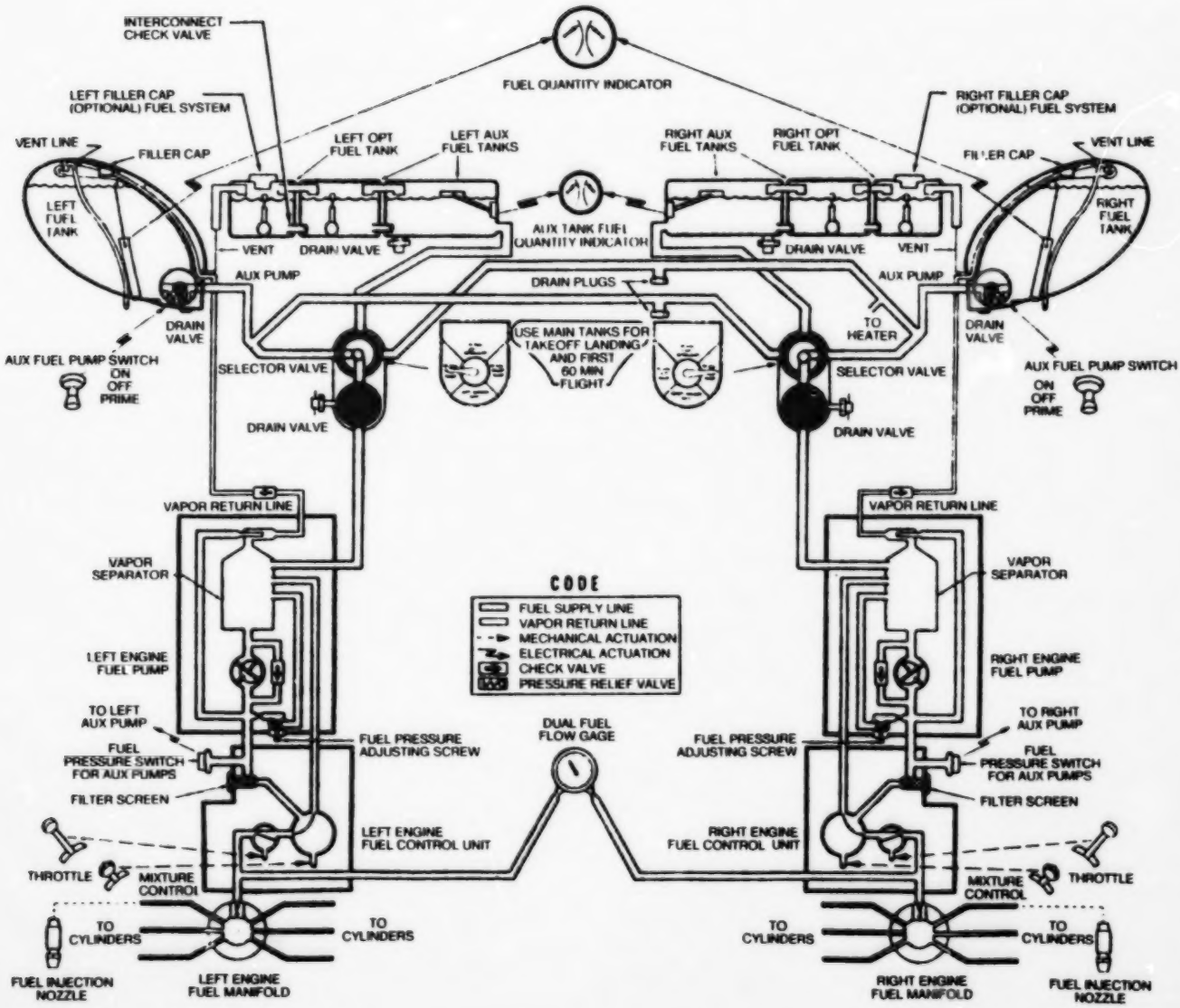
4.2.1 Type Ratings

The Board is concerned that a highly experienced pilot with low time on aircraft type demonstrated an inadequate knowledge of basic aircraft systems and crashed with usable fuel on board. Similar cicumstances were noted in the investigation of an accident involving a Transport Canada aircraft in September 1985; see occurrence report 85-H50004. In view of the severe consequences of inadequate knowledge of aircraft systems for in-flight problem solving, the Board believes that rigorous testing standards for type ratings are required. The Board will continue to monitor occurrences involving pilots with low time on type, with particular emphasis on the adequacy of current type-rating procedures.

FINAL FLIGHT PATH



FUEL SYSTEM SCHEMATIC



APPENDIX C

LIST OF LABORATORY REPORTS

The following laboratory reports were completed:

LP 4/87 Radio Master Switch
LP 5/87 Fuse Analysis
LP 9/87 Circuit-breaker Analysis
LP 12/87 Landing Gear Motor Flange Attachment

These reports are available on request from the Canadian Aviation Safety Board.

GLOSSARY

ADF	automatic direction finder
agl	above ground level
asl	above sea level
EST	eastern standard time
FAA	Federal Aviation Administration
gph	gallons per hour
hr	hour(s)
IFR	instrument flight rules
lat	latitude
lb	pound(s)
long	longitude
N	north
VASIS	visual approach slope indicator system
VFR	visual flight rules
W	west
°	degree(s)
'	minute(s)